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(54) Abstract Title
Magnetic actuator arrangement

(57) A magnetic actuator arrangement comprises switch means 15 arranged to be triggered to de-energise drive coil means when a sensor means 10a, 10b detects the arrival of an armature at one of its extreme positions. The switch means 15 may comprise transistor means activated by an electronic interface 11 in response to a detection signal provided by the sensors 10a, 10b. Sensors 10a, 10b may be provided to interact with respective collars 9 which are located on the drive shaft 6 such that they detect first and second extreme positions of the armature respectively. A battery supply 13 may be used to provide the electrical energy to the drive coils. The arrangement may comprise a bistable magnetic actuator for use in a circuit breaker mechanism. The arrangement avoids wasting battery energy on unnecessary energising of the drive coils.

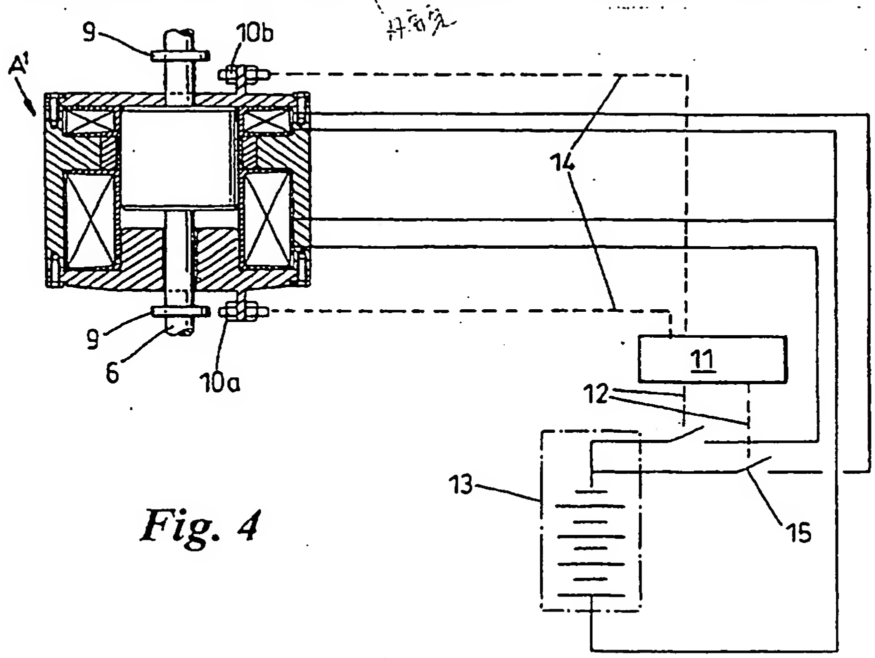

Fig. 4

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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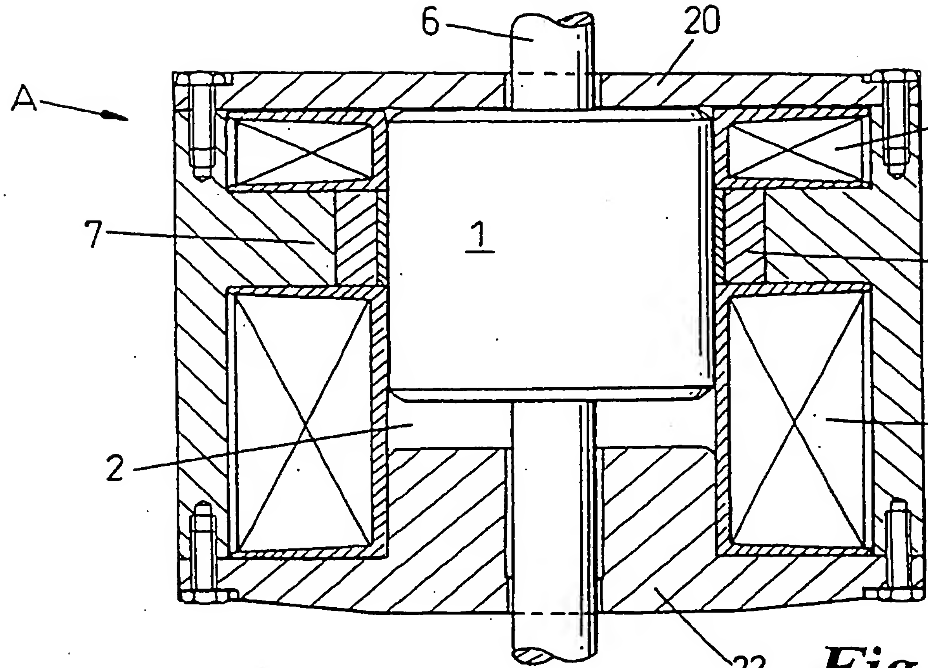

Fig. 1

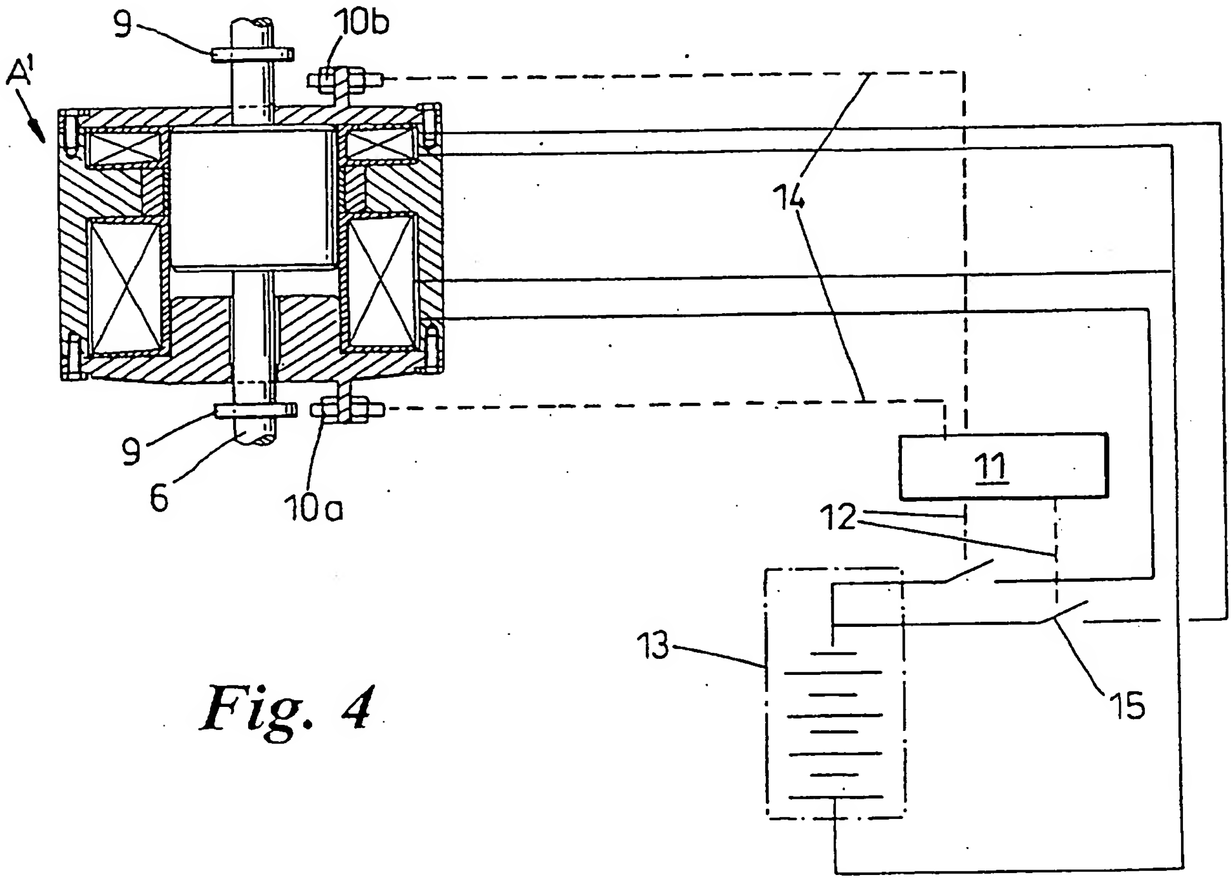

Fig. 4

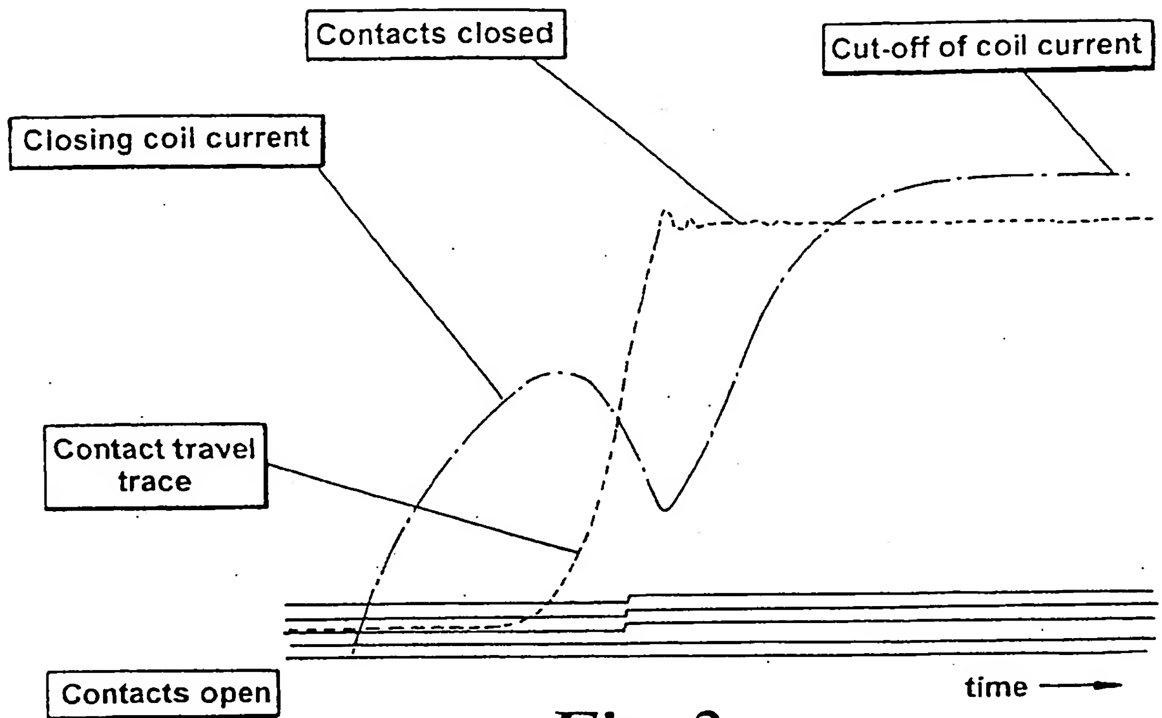
Contacts closed
Cut-off of coil current
Closing coil current
Contact travel trace
Contacts open
time

Fig. 2

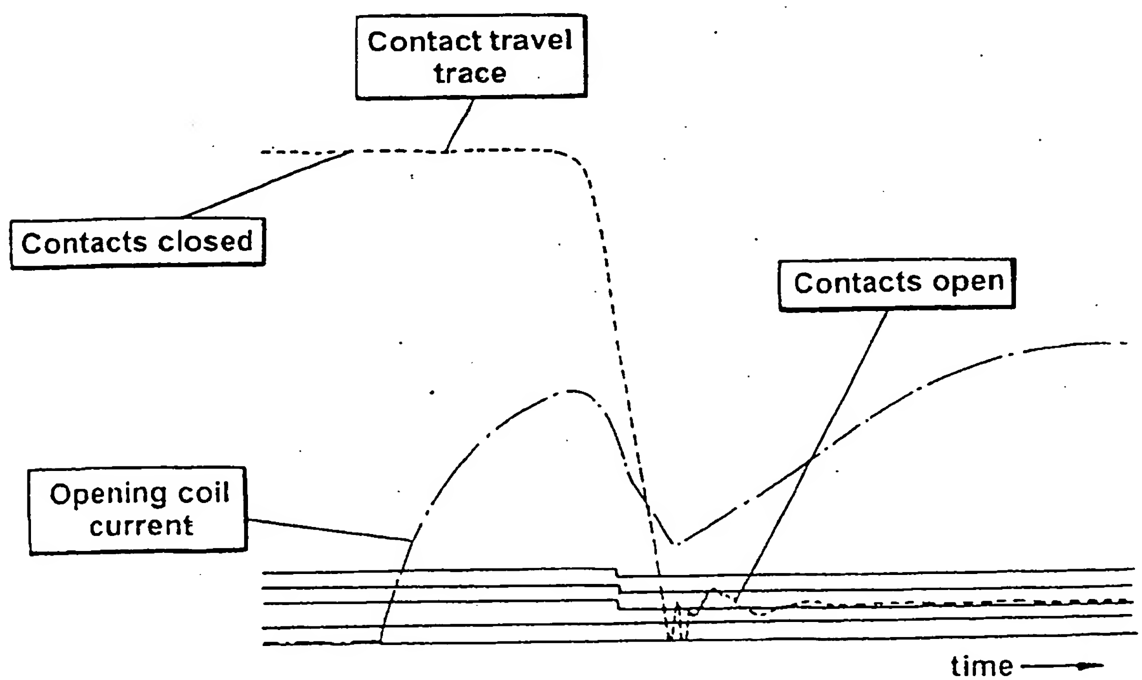
Contact travel trace
Contacts closed
Contacts open
Opening coil current
time

Fig. 3

MAGNETIC ACTUATOR ARRANGEMENT

The present invention relates to magnetic actuators, particularly of the type which are used in actuation mechanisms for switch gear.

Typically, magnetic actuators as used in switch gear mechanisms comprise a central moving armature surrounded by a set of permanent magnets and a magnetic yoke, electromagnetic coils situated at opposing ends of the actuator for urging the armature in opposing directions, and a drive shaft connected to the armature for transmitting the armature movement to a switch gear mechanism which opens and closes circuit breaker contacts. At each extreme position of the armature, an air gap is opened up within the actuator, the gap being adjacent the coil which the armature has moved away from.

Magnetic actuators are bi-stable devices, in that the armature is held at one or the other end of its stroke – corresponding to the OPEN and CLOSED positions of the circuit breaker contacts – by the magnetic flux produced by the set of permanent magnets. To open or close the circuit breaker, an appropriate one of the electromagnetic coils, the so-called "opening" or "closing" coil, is energised. The magnetic flux produced by the current flowing through the coil windings is concentrated across the air gap, thereby overcoming the force holding the armature in its initial position and causing the armature to be driven to the opposite end of its stroke. This in turn drives the switch gear mechanism and causes the circuit breaker contact position to change.

Because of the mechanical linkage between the armature and the circuit breaker moving contacts, the end of contact travel is co-incident with the end of armature travel. Hence, the useful energy consumed by the magnetic actuator coils is that which is used until the end of contact travel. Energy consumed by the coils after that point is wasted, so once the contacts have been moved from the OPEN to the CLOSED state, or *vice-versa*, the current to the opening or closing coil should preferably be cut off.

In one type of known arrangement, the current in the electromagnetic coil continues to flow until it is interrupted when auxiliary contacts open, these auxiliary contacts being

driven from the same mechanical linkage as the circuit breaker contacts. In a known alternative arrangement, a timing device is used which commands the interruption of coil current after a pre-set time has elapsed since energising of the coil.

One of the uses of magnetic actuators is in switch gear where, because of the remoteness of the installation, the power for operation has to be provided by long life batteries, such as those based upon lithium. There is clearly an economic and environmental advantage to be gained if the size of the battery pack used in this type of application can be minimised, or the number of operations can be increased for a given battery size.

The above-mentioned attempts to prevent energy wastage after operation of the magnetic actuator are only partly successful. Due to limitations of the mechanical linkage, auxiliary contacts tend to open a short time after the armature in the magnetic actuator has reached the end of its travel. The alternative timing method has to provide a current duration long enough to allow for variations in the actuator operating time, which could be influenced by the ambient temperature and the condition of the power supply. This duration will be in excess of that needed for normal operation. Hence, the timing method does not eliminate all of the wasted energy.

The present invention is therefore concerned to further reduce such wastage of energy in the electromagnetic coils of magnetic actuators.

According to the present invention, a magnetic actuator arrangement, comprising electromagnetic coil means, electrical supply means for supplying electric current to the coil means, an armature capable of moving between first and second extreme positions within the magnetic actuator under influence of the coil means, and electronic switch means for energising and de-energising the coil means, is provided with sensor means adapted to detect at least one extreme position of the armature, the sensor means being connected to the switch means to trigger de-energising of the coil means upon receipt of a signal from the sensor indicating arrival of the armature at said extreme position.

Conveniently, the switch means comprises transistor means, such as FET's, linked to an electronic interface which receives signals from the sensor means.

The electromagnetic coil means may comprise first and second coils, a coil being arranged at each end of a range of movement of the armature.

Preferably, the sensor means comprises first and second sensors, the first sensor being adapted to detect the first extreme position of the armature and the second sensor being adapted to detect the second extreme position of the armature. The first and second sensors may be arranged to control de-energising of the first and second coils respectively.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a typical known magnetic actuator;

Figure 2 shows a typical oscillogram for a circuit breaker closing operation using a magnetic actuator;

Figure 3 shows a typical oscillogram for a circuit breaker opening operation using a magnetic actuator; and

Figure 4 shows a magnetic actuator designed in accordance with the present invention.

Referring now to Figure 1, a typical magnetic actuator *A* for use in a switch gear mechanism comprises a central cylindrical moving armature 1, a set of permanent magnets 3, a closing coil 4, an opening coil 5, and a magnetic yoke 7. The magnetic yoke 7 forms part of a cylindrical housing 8 of the magnetic actuator. Attached to armature 1 as an extension thereof is a drive shaft 6, which extends through end-plates 20,22 of the actuator housing to drive a mechanism for operating circuit breaker contacts in the switch gear (not shown).

Such magnetic actuators are bi-stable devices in that the armature 1 is held at both ends of its stroke by the magnetic flux produced by the set of permanent magnets 3. Figure 1 shows a typical actuator holding the associated circuit breaker contacts in the OPEN position. Since the length of the armature 1 must evidently be less than its total range of travel within the actuator *A*, an air gap 2 is present below the end of the armature adjacent the closing coil 4 when the armature is in the position shown.

In order to close the circuit breaker, the closing coil 4 has to be energised. The magnetic flux produced by the current flowing through the coil windings is concentrated across the air gap 2 and thereby overcomes the force holding the armature in the circuit breaker OPEN position, so causing the armature 1 to be driven over to the circuit breaker CLOSED position.

To cause the actuator to re-open the circuit breaker, a reverse action to the above is carried out in that the opening coil 5 is energised and the magnetic flux within the air gap above the armature 1 is increased to overcome the magnetic flux holding the armature 1 in the circuit breaker CLOSED position, so causing it to be released and to be driven back to the circuit breaker OPEN position. The relative sizes of the two coils 4 and 5 are as shown because the circuit breaker contacts include springs which are biased towards the circuit breaker OPEN position to assist the opening coil 5.

Turning now to Figures 2 and 3, the oscillograms illustrate the energy consumed by the coils during circuit breaker closing and opening operations. The oscillograms plot current on the vertical axis against time in milliseconds. Also plotted on the same axes are the movements of the circuit breaker contacts against time.

It will be seen in both Figures 2 and 3 that the closing and opening coils 4 and 5 have a distinctive characteristic. They both draw currents which rise until the movement of the armature starts, which has the effect of increasing the inductance of the electrical circuit, thus choking the current. However, once the actuator has reached the end of its stroke, the current in both coils starts to rise again.

Because of the mechanical linkage between the armature and the circuit breaker moving contacts, the end of contact travel is co-incident with the end of armature travel. In the known arrangements, the coil current continues to flow until it is interrupted when auxiliary contacts open, which are, in turn, driven by the mechanical linkage. Alternatively, a timing device is used which commands the interruption of coil current after a pre-set time has elapsed. It will be seen that the useful energy consumed is that which is used up to the point of the end of contact travel. Energy consumed after that point is wasted.

Figure 4 illustrates how the actual end of armature travel can be detected by the use of sensors, leading to the interruption of the coil current in the shortest possible time. The magnetic actuator A^1 is similar to that described in relation to Figure 1, with the exception of the features described in the following paragraphs.

In the embodiment shown, a metallic collar 9 is rigidly attached to each end of the actuator drive shaft 6 and arranged to pass within the operating range of two proximity sensors 10a, 10b which could be of the reed, capacitive, inductive or optical type. Such proximity sensors are well known in themselves and need no further description to the expert person. Sensor 10a controls cut-off of current to the closing coil 4 and Sensor 10b controls cut-off of current to the opening coil 5.

As an alternative to the use of collars 9, a hole or recess in the shaft 6 could replace either or both collars. If the shaft 6 were to be provided with a collar at one end and a recess at the other end, the corresponding states of the sensor signals could be used to indicate a change of state of the armature corresponding to the change of state of the circuit breaker contacts, i.e. fully open or fully closed.

The output from each sensor 10a, 10b when it detects the end of armature travel, is transmitted via wires 14 to an electronic interface 11, which in turn initiates coil current interruption of the battery power supply 13 via links 12 and switches 15. Switches 15 conveniently comprise FET's and may be provided on the same circuit board as interface 11.

To minimise the power drain on the power supply, the electronic interface 11 is arranged to energise and de-energise the sensors 10a, 10b at the same time as the corresponding actuator coils 4 or 5.

It will be seen from Figures 2 and 3 that the power used in energising the closing coil 4 is significantly greater than the used for energising the opening coil 5. This is because the closing coil 4, in addition to closing the circuit breaker, also has to store energy in the above-mentioned spring system of the circuit breaker contacts for a subsequent opening operation. Because of this disparity of energy consumption, it may be economically worthwhile to fit only one sensor 10a for controlling the closing coil 4, and to omit sensor 10b.

It is also evident from Figures 2 and 3 that if, as is the intention of this invention, the interruption of coil current is arranged to coincide with the end of armature travel, the power consumption will be much less than would otherwise be the case, perhaps less than half as much.

A further advantage of the invention can be seen with reference to Figures 2 and 3. The current taken by coils 4 and 5 passes through a minimum value at the time the circuit breaker contacts, and therefore the armature, reach the end of their travel. Interruption of coil current at or about this point will significantly reduce the electrical stress on the coil current switching devices 15.

CLAIMS

1. A magnetic actuator arrangement, comprising electromagnetic coil means, electrical supply means for supplying electric current to the coil means, an armature capable of moving between first and second extreme positions within the magnetic actuator under influence of the coil means, and electronic switch means for energising and de-energising the coil means, is provided with sensor means adapted to detect at least one extreme position of the armature, the sensor means being connected to the switch means to trigger de-energising of the coil means upon receipt of a signal from the sensor indicating arrival of the armature at said extreme position.

2. A magnetic actuator arrangement according to claim1, in which the switch means comprises transistor means linked to an electronic interface which receives signals from the sensor means.

3. A magnetic actuator arrangement according to claim1 or claim 2, in which the sensor means comprises first and second sensors, the first sensor being adapted to detect the first extreme position of the armature and the second sensor being adapted to detect the second extreme position of the armature.

4. A magnetic actuator arrangement according to any one of claims 1 to 3, in which the electromagnetic coil means comprises first and second coils, a coil being arranged at each end of a range of movement of the armature.

5. A magnetic actuator arrangement according to claim 4 as dependent on claim 3, in which the first and second sensors are arranged to control de-energising of the first and second coils respectively.

6. A magnetic actuator arrangement substantially as described herein with reference to Figure 4 of the accompanying drawings.

The Patent Office

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Application No: GB 9912489.3
Claims searched: 1 - 6

Examiner: John A. Watt
Date of search: 22 October 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1P (PC, PBA); H1N (NEG, NEH, NEJ, NEK); H3P (PDLR)

Int Cl (Ed.6): H01F 7/06, 7/121, 7/122, 7/16, 7/18; H01H 47/00, 47/04, 47/22, 47/32, 51/27

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X, Y	GB 1594578	(HART) see whole document	X: 1, 4 Y: 3, 5
X, Y	GB 1532504	(BURROUGHS) see figs.3 & 5 and page 1, lines 11 - 19.	X: 1, 2 Y: 3, 5
X, Y	GB 1532503	(BURROUGHS) see figs.3 & 5 and page 1, lines 11 - 19	X: 1, 2 Y: 3, 5

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
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